TEACHWITHPORTALS™

Subject: Math

Title: Volume of Figures and the Puzzle Maker

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School / Organization, City and State / Province:

Shoreline, WA

Grade Levels: 6 or 7

Common Core Standards Met:

6th: Solve real-world and mathematical problems involving area, surface area, and volume.

6.G.4. Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. ~Note: the surface area elements appear in a later lesson. ~ Apply these techniques in the context of solving real-world and mathematical problems.

7th: Draw, construct, and describe geometrical figures and describe the relationships between them.

7.G.2. Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.

7.G.3. Describe the two-dimensional figures that result from slicing three-dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

Time needed for lesson: Two class periods

Overarching Question and Objectives:

How is volume different than surface area? How does changing the dimensions of a rectangular prism impact the volume?

- Students will be able to define volume and explain how it is different than area
- Students will be able to calculate the volume of various rectangular prisms
- Students will be able to make changes to a figure to derive a specific volume

APERTURE LABORATORIES

Summary of lesson:

In this lesson students explore the concept of volume by manipulating the dimensions of the test chamber in the Puzzle maker. They gain practice working with the formula for rectangular prisms, explore changing the dimensions of the room and their effects on volume as well as differences in volume and surface area. More complex figures are introduced as students manipulate the dimensions into rooms that are not perfect rectangular prisms and are then faced with finding the volume of more irregular shapes.

Vocabulary:

Volume – the number of cubic units needed to fill a 3-D figure

Surface area – the sum of the area of the bases and lateral faces of a 3-D figure

Teacher materials needed:

If possible, a computer that will allow you to project the Puzzle Maker for class discussion purposes.

*Some sort of demonstration rectangular prism or cube (such as a Rubik's cube) to illustrate volume.

Student materials needed:

* The Puzzle Maker

* Paper and pencil

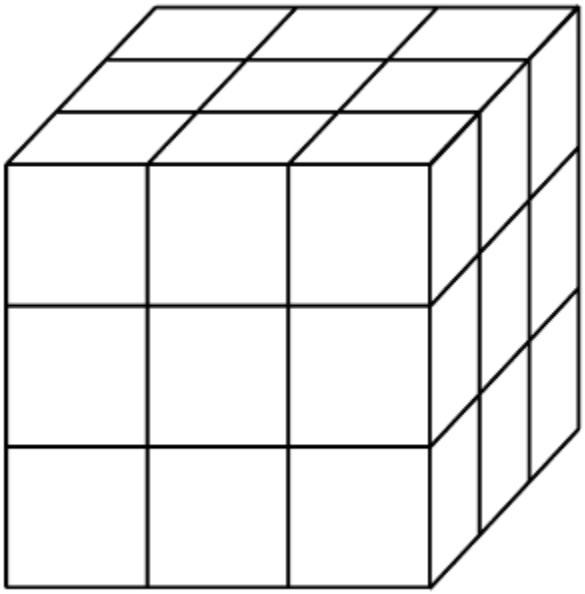
Lesson Plan:

Begin the lesson by showing the basic room in the Puzzle maker in front of the class. *Ask students to describe what it would mean to find the surface area of that room.* (If you have completed the related lesson in this series on surface area, you could talk about painting the entire room floor-to-ceiling with the pink paint).

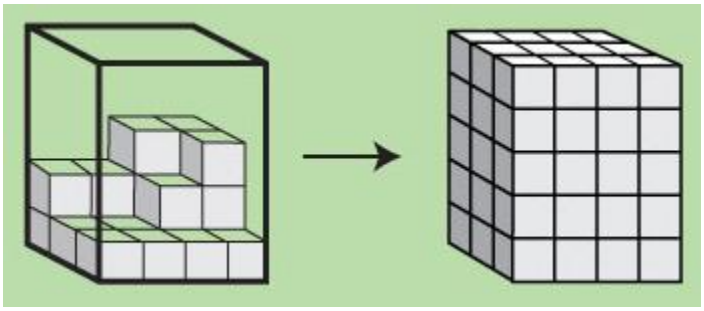
Ask students how they would differentiate surface area from "volume." You can reiterate (or explain if no-one knows the difference) by explaining that the volume of the room would explain how much of something the room can hold (for instance if we were going to fill the room with pink paint).

Explain that when we are talking about volume we are referring to how many cubic units an object can hold.

Note: If you have a volume demonstration object, this might be a great time to show it with example unifix-cubes inside of it, or, a simple Rubik's cube would illustrate the same point in a concrete manner.



Even showing a simple image such as this and asking students to explain how many cubes are in the figure is a good start.



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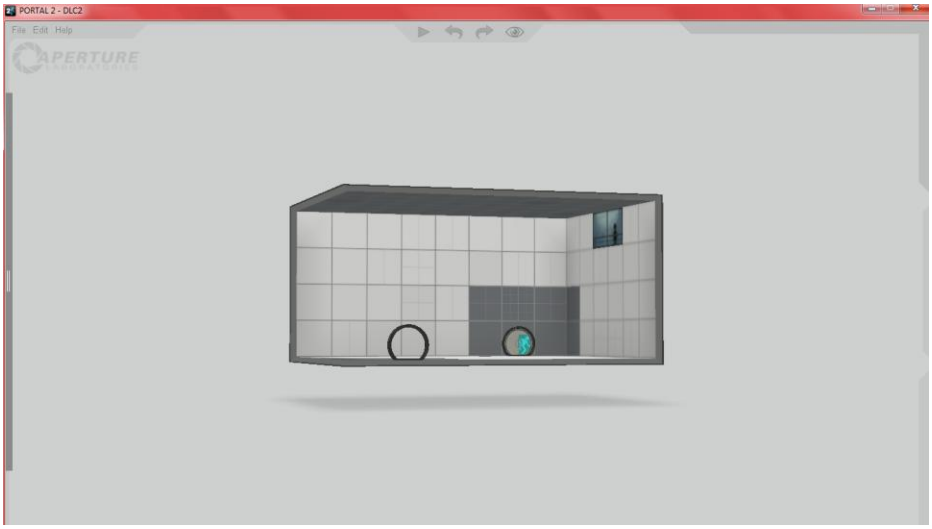
A graphic such as the one above can also help to illustrate the point.

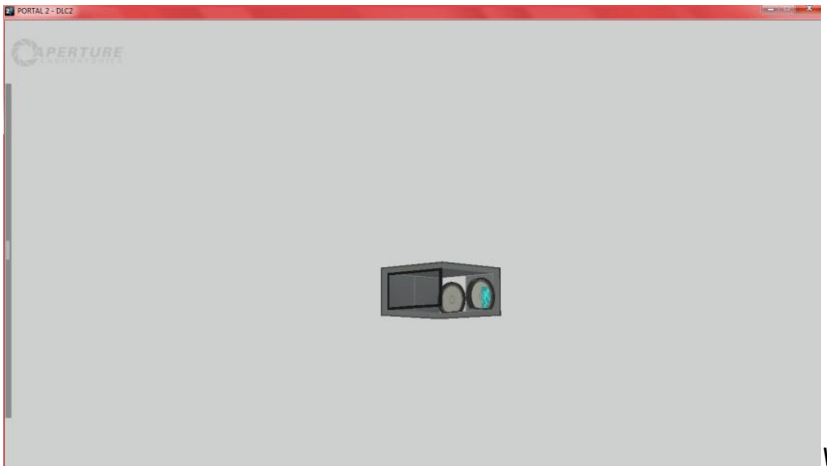
Try to encourage students to come up with another way besides counting to figure out the volume of the shapes. Remind them of the area formula and how we are now adding a new element, depth, to the concept of area.

Make sure they have the formula: $V = lwh$ down before moving back to the Puzzle Maker.

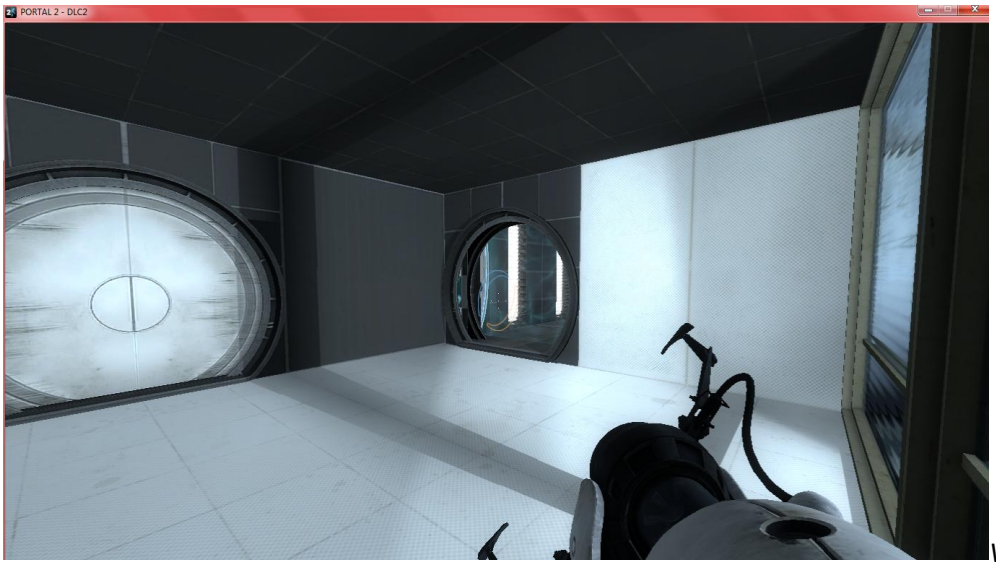


Have students work in pairs to figure out the volume of the main Puzzle Maker screen. Ask them to explain their thinking. (192 cubic units)

Now, tell students you are going to have them experiment with the size and shape of the room. Their task for the next several minutes will be to create a room with the least possible volume. Once they think they have it, they should record the dimensions of their room and calculate the volume. (Remind them they can move the observation room and doors).



View from outside the room



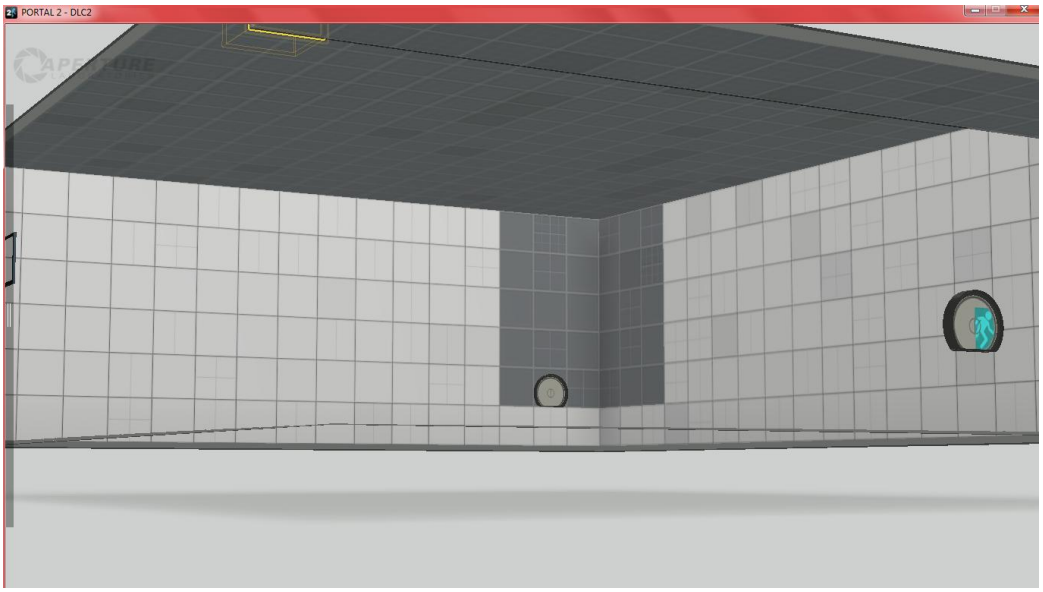
View from inside

Keep in mind there are some constraints in this room with the doors and observation room, but what can they do with the room itself? An example is shown above… a 1x2x4 room.

Once the majority of students have completed the task, have them share their rooms with the class and discuss and defend their test chambers. On a piece of paper have them note the surface area of the room next to their volume. Make sure they get the units correct (square versus cubed) and have them have a buddy partner check their calculations.

Explain that now the challenge is flipped. You would like students to try to create the room with the largest volume possible. Encourage them to play around with the depth of the room. At this juncture

they may just try to make a “really big room.”



An example of a “big room.”

Again, once students have constructed their rooms with large volumes, have them calculate the volume and surface areas on their papers and discuss and defend their ideas with the class.

As they are working on this task, create a room in your own Puzzle maker that is more complex in terms of is volume. Perhaps something that has levels of varying heights that make the calculations more difficult. See below for a fairly complex example.

This was a challenge room I created for my most advanced students. Something simpler would definitely work!

Project the image of your room and ask students to try to rebuild the room you made and calculate the volume of the room you've created. They may work in pairs but they need to be able to explain their reasoning and methodology for their calculations.

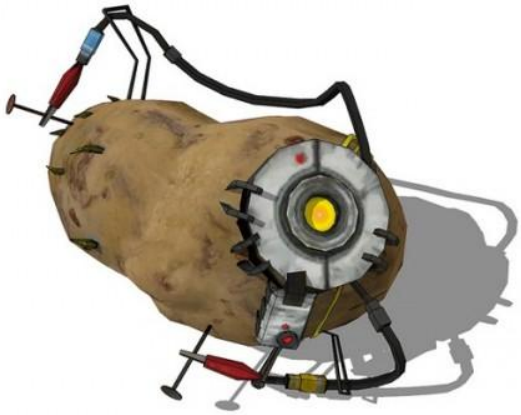
Perhaps they will divide the room up into different sized rectangular prisms, they may find the volume that they will need to "subtract" from the total volume. By having everyone work on the same problem at the same time and then discussing the various options for solving, it allows the entire group to gain insight into the problem solving process.

At this point, it would be good to check in and see if students have any questions about calculating volume. They should being to work on the "Smart Potato" worksheet below. The first three questions would be great to do in class if possible. That way teams of students can work together and look over each other's work. The fourth problem should be done independently (could be homework if students have laptops) and shared when it is complete.

The teacher should rotate around, be helping students with calculations, encouraging students to explain their calculations, reasoning and work. In particular, encouraging students to draw

observations about the surface area and volume, the various volumes and their strategies for working with the volume of more complex figures.

Although we want to encourage students to be creative with their volume problems, we don't want them to create rooms that are impossible for them to solve. Encourage them to work within their skill level.



Now That's One Smart Potato!

Although we may not usually think of potatoes as being particularly intelligent objects, in *Portal 2*, there is a scary-smart robot that temporarily becomes a Potato named GLaDOS that is out to cause grief, especially to us. This highly intelligent potato has some problems for you to solve involving volume and I would suggest we do as she says…. She appreciates accuracy….a lot. ☺

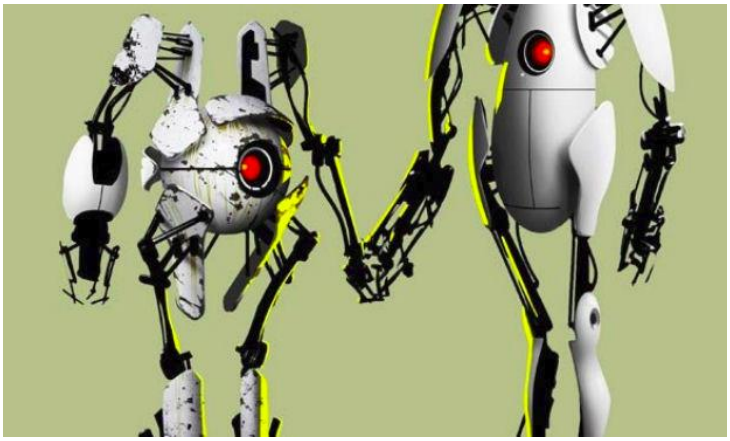
Potato Problem #1

Using what you know about surface area, create a room that has a volume that meets the following specifications: $320 < x < 400$ cubic units.

Once you have created a room that meets those requirements, please write the dimensions below.

Draw a sketch of the room.

*****Note….no potato is perfect. At this point, align yourself with a "Potato Pal" who will look over your work and your test chambers. You will also need to look over their work. Accuracy, people. *****


We work better as a team!

Potato Problem #2

Create a room with the Puzzle Maker that is relatively flat but has a large volume.

Write the dimensions of the room.

Calculate the volume of the room.

Make a sketch of the room.

Find the surface area of this room.

Potato Problem #3

Create a room with the Puzzle maker that is quite tall but has a volume equal to (or close to) the volume in Potato Problem 2.

Write the dimensions of the room.

Calculate the volume of the room.

Make a sketch of this room.

What is the surface area of this room?

What do you notice about the two rooms when you compare them to one another? Be prepared to discuss.

Potato Problem #4

Alright, now here is the real challenge. You need to create a room that has a more challenging volume. Not just a plain old boring rectangular prism, but something with some structural "uniqueness" to it. Here are the steps to help you:

(1) Design your room (don't worry about what's in it, just the room itself) But make sure you like it!
(2) Carefully rotate the room and look it at from various views to really familiarize yourself with it
(3) Calculate the volume of the room….show your work below
(4) Take a screenshot of your room to print out
(5) Save your test chamber so that it can be accessed again

Tomorrow your potato pal and you will trade rooms and solve them for volume!